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**Annals of Biological Research, 2013, 4 (1):307-316**
*(http://scholarsresearchlibrary.com/archive.html)*

Annals of Biological Research
Scholars Research Library
**ISSN 0976-1233**
**CODEN (USA): ABRNBW**

# Milling Process in Moroccan barley mills

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**ABSTRACT**

*A survey has been conducted to explore industrial milling process in 31 Moroccan barley mills that produce semolina and flour for human consumption. The results of the survey have revealed that:*
*- On third of barley mills surveyed are equipped with pre-cleaning machine used to reduce the charge of dockage before storing barley grains in silo or warehouses ;*
*- Barley grains are thoroughly cleaned by running through two essential cleaning machines: cleaner-separator and destoner ;*
*- Dehullers are installed right after the destoner to take out the hulls and parts of grain pericarp by abrasion with an average of two successive runs. The rate of dehulling obtained varies from 25 to 30 % ;*
*- Dehulled grains are processed without tempering, by millstones, metallic roller mills or a combination of both.*
*- The sieving of milling products is performed by plansifters or by vibro-sifters. A high proportion of sieved material goes to the purifiers where different types of semolina are extracted for bagging;*
*- Barley plants have lower milling capacities (12 to 80 metric tons per 24 hours) compared to durum and common wheat mills ;*
*- The production equipment is very outdated and comes from the modernization of durum or bread wheat mills ;*
*- Barley millers stock up mainly of the market of the import.*

*The results obtained have allowed us to raise the main parameters indicative of the value of barley semolina and develop model diagrams for cleaning, dehulling and milling barley.*

**Key words**: Barley, milling, semolina, quality, diagram.

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## INTRODUCTION

Barley (*Hordeum vulgare L.)* is the most widely cultivated cereal in Morocco. This crop occupies on average 41% of the total area of the main cereals (wheat, barley and maize), and provides 30% to the total cereal production. Barley grows in all agro-climatic zones due to its adaptation to soil, climatic conditions, and to its strong integration into farm systems of vegetable and animal production.

Traditionally, Moroccan people are major consumers of barley. A variety of dishes is made out of grain barley products, including soups, and semolina for making couscous, or barley flour for baking. These products (flour and semolina) are both manufactured by industrial and artisanal mills.

The sector of grain milling, as for all productive sectors in Morocco is composed of a traditional subsector, and industrial sub-sector. The number of artisanal mills is about 10000 plants. More than 90 % of them are localized, particularly in rural zones. Their grinding activity varies considerably each year according to the national level of

grain production. Grain grinding was assessed at 2 million tons per a year for human and animal consumption [1]. Barley grinding represents 16.8 %, 12.8 % of which is allocated for human consumption and the remaining 4 % is assigned for animal feed. The grinding barley share of the artisanal mill showed a notable decrease. It has gone from 28 % in 1989 to 17 % in 1999.

As for the sector of milling industry, it comprehends 202 industrial plants shared out between barley mills (commonly called orgeries), 14, (7 % of the total), 36 durum plants (18 %), and 152 common wheat plants (75 %) [2].

Industrial plants deal, for products trade, with commercial wholesalers, retailers or directly with bakeries. Barley mills plants have provided significant efforts to be modernized in order to comply with Moroccan regulations [3].
Barley millers have set their milling diagrams for almost five decades of activity in order to meet consumers' needs. In this field, Moroccan millers are a good international reference. However, studies and publications on the barley milling value and technology are scarce and insufficient, because barley is almost exclusively and world widely used for animal feed and some industrial uses.

In this work, we propose to study the technological process of barley milling based on a survey of barley plants in Morocco. Typical diagrams for cleaning, hulling, and milling will be set up later on.

## MATERIALS AND METHODS

The methodological approach used for this study builds on a survey on industrial plants of barley mills in Morocco. The survey covered all the units that produce barley products. The exhaustive list of barley mills was obtained from Morocco's cereal office (ONICL), a government agency. For this survey, a questionnaire was conducted to fathom the barley technical milling aspects.

The questionnaire comprises two parts; the first part aims at identifying the visited plants and questioning millers regarding evolution outlook for the barley sector; as for the second part, caters for the assessment of the barley mills' facilities so as to carry out the applied technology for barley cleaning, dehulling and grinding.

## RESULTS AND DISCUSSION

### 3.1. TYPOLOGY AND PLANTS NUMBER

The survey on the barley sector displays the existence of two types of industrial plants; plants dealing only with barley, and those that are mixed witch dealing simultaneously, besides barley, with common and/or durum wheat. The total number of these two types is 31, having a barley grinding capacity of 1153 metric tons per a day that is approximately 3 % of the global capacity in Morocco. The distribution of this capacity by type of flour-mill is presented in table n° 1.

**Table 1: Distribution of the grinding capacity of barley**

| Type | grinding capacity | | number of plants | |
|---|---|---|---|---|
| | metric ton / 24h | % | number | % |
| Mixed units (common wheat and barley) | 185 | 16% | 4 | 13% |
| Mixed units (durum wheat and barley) | 435 | 38% | 13 | 42% |
| Specialized units (orgeries) | 533 | 46% | 14 | 45% |
| Total | 1,153 | 100% | 31 | 100% |

Out of 14 units specialized only in barley grinding; three are set up in the region of Laayoune, in the south. These units produce "gofio", namely flour produced from roasted barley or maize.

### 3.2. INSTALLED CAPACITY AND GEOGRAPHICAL DISTRIBUTION

Barley mills are small-sized units. They are essentially localized in Casablanca, Marrakech and in Safi-Essaouira-Agadir line. The capacity of these plants differs from minimum of 12 to a maximum of 80 metric tons per 24h.
As for the geographical distribution (Table 2), it shows a strong concentration at the level of two main regions: Casablanca (30 % of the capacity and 35 % of total number) followed by Tensift Al Haouz's region (24 % of the capacity and 23 % of the total number).

**Table 2: Regional distribution of the number and barley grinding capacity**

| Economic Region | Capacity metric ton / 24h | number of plants |
|---|---|---|
| Grand Casablanca | 344 | 11 |
| Tensift Al Haouz | 275 | 7 |
| Doukkala Abda | 214 | 4 |
| Chaouia Ouardigha | 140 | 3 |
| Laayoune Boujdour | 72 | 3 |
| Meknes Tafilalt | 60 | 1 |
| Souss Massa | 48 | 2 |
| **Total** | **1,153** | **31** |

Apropos of the date of installation, the barley plants or lines have begun their activity since the 40s. 23 % of the plants started their activity before 1985. 35 % set off their activity after 1985 (date of prices liberalization of barley and durum wheat in Morocco). The opening of the remaining 42 % units took place after 1996, a date in which the law of 12/94 came into force. The oldest unit still in service has started its activities in 1948.

### 3.3. CHARACTERISTICS OF BUILDINGS

The global average surface occupied by barley mill is about 1700 $m^2$. For mixed plants, the average surface is 6200 for barley/durum and 11400 $m^2$ for bread wheat/ barley. These values find their justification in the necessity of having space being enough for accommodating the arrangements and the grinding installations of another cereal, other one than the barley.

The number of floors for an industrial flour-mill is an indicator of the technological level of the installations, and reflects its degree of modernization. Mill barley is generally built in 2 floors. The mixed units may have a number of levels varying from 3 to 5.

### 3.4. VALUE OF BARLEY SEMOLINA

#### 3.4.1. Definition

Semolina value can be defined in the capacity of grains to give a good yield in pure semolina, of uniform particle size and selected for various uses [4].

Concerning mill barley, the barley semolina value can be defined as being the ability to give a good yield in pure semolina (*dchicha or balboula*) and a homogeneous size with limited energy consumption.
Semolina value is appreciated by the evaluation of the physical and chemical criteria, affecting, in industrial conditions, the diagram of manufacturing. We consider, at this level, cleaning of barley, dehulling, energy consumption, total extraction of finished products and their quality.

Barley for the mill processing should be uniform, free from discolored grain, plump, white, medium hard and thin-hulled [5-6]. When selecting barley for milling, the following criteria should be examined: Trimming for local barley, dehulling properties, grain size, test weight, moisture, falling number, protein content, grain damage and discoloration and desired properties for second transformation.

In our case, the survey showed that for imported barley, commercial contracts are based on specifications related to moisture, test weight and dockage. However, the survey demonstrated downright absence of material for the quality control of the raw material and finished products. In many cases, particularly in “orgeries”, barley evaluation is based only on a visual appreciation.

#### 3.4.2. Trimming

Handling of local barley raises severe problems during its reception, storage and cleaning. The long extremities of grains can cause an obstruction of the outcomes of storage bins and present difficulties of separation with bigger impurities than barley.

#### 3.4.3. Dehulling properties

Through good hulling properties for barley, hulls are easily removed from the kernel and maintain a high percentage of hulled barley. Poor hulling properties would cause greater loss of endosperm when attempting to remove hulls during the dehulling process [7].

The hulling also remains a necessary operation for determining the heated grains and the texture of grains.

**3.4.4. Size and grain size**
The grain size represents the distribution of the kernel size that is obtained by sieving a sample on a sieve battery with specific dimensions [8]. The barley kernel size influences the dehulling and milling operations, particularly the machines' adjustment. The plumped barley kernel gives a good hulling yield. When necessary, the line of barley processing can be strengthened by a calibrator that separates kernels in different sizes. However, this machine is not available in Morocco.

**3.4.5. Test weight**
Test weight is one of the parameters mostly used in Morocco during the commercial transactions of cereals [9]. This parameter is also considered as the sizing of the storage capacity. The considered values are 58 and 66 kg / hl for the local barley and the imported one, respectively. However, the test weight is influenced by several parameters, particularly: dockage content, barley homogeneity, temperature, kernel friction and grain moisture [4].

**3.4.6. Moisture**
It has a major importance in the analytical, economic and nutritional plans. Analytically speaking, the moisture content is the basis of differentiation between the qualities of two products of barley, whereas on the economic side, a small difference for moisture may carry away significant effects in the market value when the commercial transaction concerns important quantities. On the sanitary side, moisture has an influence on the barley preservation during storage [8].

**3.4.7. Protein**
It is an important parameter on the nutritional side. Proteins of cereal go for more than two thirds into the daily food ration of the Moroccan population. Protein content has an influence on the use of the products of barley (bread-baking, soup, manufacturing of couscous).

**3.4.8. Falling number**
It allows for the estimation of richness in alpha-amylase and the degree of sprouting.
The remaining criteria also have their importance and influence the ability of barley processing in milling and the economic profitability of the grinding process.

**3.5. BARLEY MILLING PROCESS**
**3.5.1. General state of the equipment**
The survey conducted at barley plants showed that the production equipment is very outdated. Indeed, the grinding barley material is often a recycling material and comes from the modernization of durum or bread wheat mills.

**3.5.2. Reception, pre-cleaning and storage Barley**
The imported barley is received in bulk in the mill by means of dump trucks. On the other hand, barley of local production is generally delivered in 70-80 kg bags.

These trucks are weighed, and then headed to the pit of reception, surmounted by a metal grid; the role of which is to retain the big foreign material. The latter risks, in case of their presence, damage elevators and cleaning machines.

The role of pre-cleaning is to remove a part of coarse and fine impurities from the grain by sieving. The hourly capacity of reception must be superior of at least 3 times than that of the mill. For local barley, the deburring must be practiced to avoid obstruction of the outlet of the storage bins. The operation consists in freeing barley of its too long extremities and in polishing the surface of the grain to facilitate its cleaning.

In addition, it is necessary to equip this section with a magnet to eliminate fire risk or explosion and a separator to remove large impurities. In terms of the raw material weighing, 18 units out of 31 have a weighbridge. Besides, the balances of circuit become rare at the level of barley Mills. The survey showed that barley is generally put in stock without pre-cleaning. Imported barley is cleaned at origin before export. However, certain units (10 units out of 31) are equipped with pre-cleaning machine as a separator equipped with an aspiration channel.

The pre-cleaned barley is then stored in warehouses or in metal or concrete silo. The survey showed that the storage capacity can cover more than two months of grinding and consists of 42% warehouses and 58% of silos. Barley has a test weight less than that of wheat. Therefore, the same volume inside the machines and transport elements (elevators, screws, etc..,) has a capacity of barley lower than that of wheat. This difference can reach 30 to 40% depending on the condition and design of machines, the quality and degree of trimming barley.

The study of this section reveals that the pre-cleaning machines can be installed are: weighbridge, magnet, scourer only for local barley for removing large local barley beards [10], separator with aspiration channel and transportation equipment.

### 3.5.3. Cleaning barley

The process of cleaning barley depends on the load of dockage that it contains. This operation aims to remove foreign materiel (sand, stones, metal, insects,..). If the impurities are not eliminated, the quality of the product will be affected. It is to note that the metallic particles can damage machines.

How does that really take place at the level of the units? The survey demonstrated that the circuit of barley cleaning varies from one unit to another. The magnet, separator classifier and destoner exist in all the investigated plants (31/31). In certain barley mills (30% of surveyed mills), the work of these machines is completed by a battery of indented separator for removing and grading round and followed by a scourer machine.

In the production units of the gofio, we found a rotating drum with a burner for roasting grain, followed by a tray with a palette for cooling.

For a barley mill, we recommend for this section the following machines: magnetic device, separator classifier, destoner, indented separator, scourer with an aspiration channel, dust collectors as filters or cyclones and transportation equipment.

### 3.5.4. Dehulling

- **Dehulling machine.**

Dehulling is a key operation in barley mills. A strong emphasis should be gained in order to have an optimal or product yield with moderate energy consumption. A barley dehuller involves removal of the hulls through abrasion and friction between a grinding medium and screen jacket. It consists of a vertical machine that is equipped with three to eight abrasive disks, and covered with carborundum or emery, which quickly turns around a vertical axis inside a drilled cylinder [10].

The operation of this machine involves feeding the barley from the top through a sight glass. As the barley descends, filling the space between the emery rings and the perforated screen jacket surrounding the rings, it is subjected to friction among the kernels, stones and the screens. This friction and abrasion loosens and, ultimately, detaches the hulls. Such frictions does generate heat; therefore, to control the temperature, air is allowed to enter through the rotor area at the top, which helps direct the detached hulls through the screen perforations. This suction air with hulls is carried over to a filter or cyclone [7].

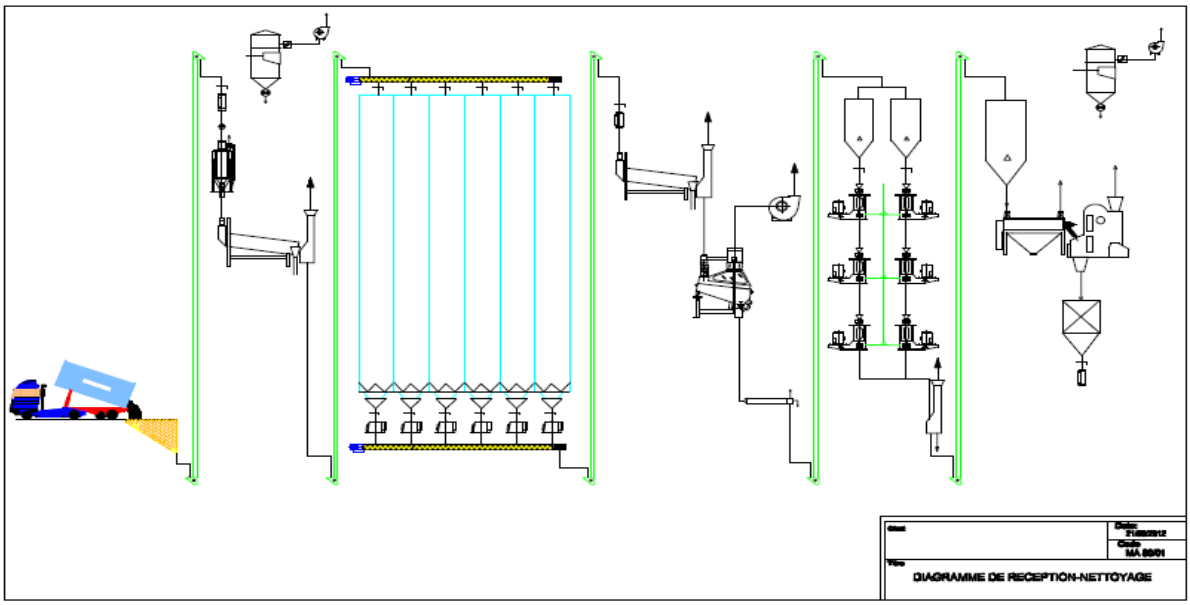


**Figure 1: Diagram of reception, cleaning and dehulling in a barley mill**

Depending to their hourly capacity, barley dehullers are set up in series and in parallel. The survey showed that the number of dehulling's passages varies from 1 to 5 with an average of 2.

Between passes dehulling, deposits are installed for cooling barley and to ensure dehullers continuous feeding. The survey has proven that the installation of dehulling machines in barley mills is arranged according to several plans (X, Y, Z ) with: X: total number of dehullers, Y: number of dehullers series and Z: number of dehulling machine by serie .

The most common plans of installation of the dehullers are: 221 - 313 - 422 - 331-623 - 414 - 933. The process of dehulling is generally based on 2 or 3 passages. As regards their low capacity, dehullers are placed in series by 2 or 3 according to the capacity of the mill. The number of dehullers in a barley mill varies from 2 to 9 machines. The illustration (2) shows a typical diagram for reception, storage, cleaning and dehulling in a barley mill.

- **Dehulling yield.**

Dehulling is part of the milling process that produces blocked (dehulled) barley, which gives as a final stage semolina and barley flour after passage by roller mills or stonemills. The processed barley is obtained by the progressive withdrawal of envelopes, bran, and germ by abrasion. Bhatty reported that the first stage of dehulling can eliminate 7 to 14 % of the weight of the grain [11]. Further abrasion results in the removal of seed coat (testa and pericarp), aleurone, subaleurone layers, and the germ, leaving behind a central endosperm rich in carbohydrates (largely starch and ß-glucanes) and in proteins (hordeins and glutelins).

The final product of this phase may not constitute more than 60-70 % of the initial weight [11], the average being 67 % [6].

Han reported pearling yields of 59-63% for barley and 67-71% for hull-less barley in Korea [12]. During the dehulling process, the hull and seed coat largely appeared in the 0-11 % fraction and the germ and aleurone in the 11-25% fraction [13].

Bhatty reported that dehulling rates between 30 and 40% are highly desirable, as at these levels insoluble dietary fiber (IDF) and acid detergent fiber were minimal, whereas soluble fiber and ß-glucans were maximum [11].
The survey evinced that the rate of dehulling obtained at the level of industrial units varies from 25 to 30 %. And this applies for imported barley as well. The results remain very interesting compared to the aforementioned yields.
Furthermore, products stemming from barley grinding can be classified according to their size grading:

- granulated product: Semolina of barley (*balboula or dchicha*) marketed under coarse semolina, medium semolina or fine semolina ;
- fine product : barley flour.

The production rate of these two products varies from one mill to another. It depends on the barley quality and the equipment used. Diagrammatic presentation of barley processing is shown in figure 2.

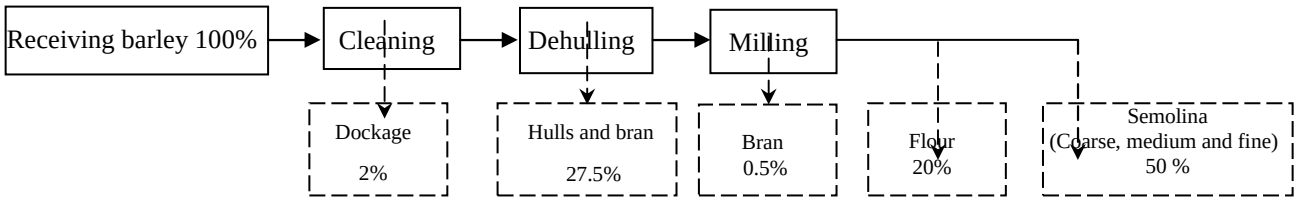


**Figure 2: Diagrammatic presentation of barley processing**

Besides to these two products traditionally known, barley industry in Morocco launches on the market two other products:

- Dehulled barley (pearl): product of the dehulling barley industrially pure and clean;
- Herbel barley: product of the coarse grinding of dehulled barley.

**3.5.5. Tempering**

In Morocco, barley is milled without any addition of water. The expected product is semolina; flour being a by-product. However, Sarkar reported that some varieties grown in different parts of the world are extremely hard and very low in moisture [7]. It may be impossible to mill them without any addition of water. Therefore, it is compulsory to practice a light tempering. This operation is generally applied after dehulling because humidification renders it difficult.

The dehulling operation warms barley. Passage through an aspiration channel is required before storage because it helps avoid condensation on the surface of grains.

**3.5.6. Second cleaning**

In the stage, scourer machine is applied for the intensive surface treatment**.** Dehulled grains are cleared of any tracks of dusts. The machine is, generally, equipped with strong aspiration for recovering impurities.
Our survey showed also that this operation is not common at barley mills. It is practiced, especially by some mixed units. We found that only 4 out of 14 investigated "orgeries" (specialized units) carry out this operation. It emerges that dehulled barley goes directly to storage in bushels for milling.

At this point, barley grains are clean, dehulled and ready for further processing.

**3.5.7. Barley milling**

- **Milling yield**

Barley can borrow the same equipment traditionally used for wheat grinding [11**].** However, barley reacts differently than wheat to conventional roller-milling. Barley bran is brittle and shatters regardless of tempering conditions, unlike wheat bran which separates as large, stable flakes and can be separated from the flour by a simple sieving [10].

Bhatty (1993) reported that barley can be milled, fry or tempered, with the equipment routinely used in wheat milling [11]. Korean workers milled hulled and hull-less barley tempered to 14 and 15% moisture, respectively in a Buhler Mill [14]. The flour yields varied from 61.2 to 74.3%. McGuire reported milling yields of 16 diverse genotypes of barley, tempered to 13% moisture, in a similar mill [15]. The average flour yield was 68% with a range of 51-72%.

In 1993, Bhatty reported hulled barley milling under different tempering conditions (8 - 22 h) and moisture (9 - 10%) in an experimental mill using a modified short flow procedure [11]. The flour yields obtained varied from a range of 69.7 to 72 %. The coefficient of variation for flour yield was 1.4% for bran 3.3%, indicating that barley can be dry-milled to consistent flour and bran yields.

In our case, the milling yield varies from a range of 70 to 75%. The average extraction rate of semolina was 50 % with a range of 48 to 52%. These values go hand in hand with the previously mentioned works.

- **Milling diagram**

The milling of barley, practiced at the level of the surveyed mills, is made by means of millstones, metallic roller mills or a combination of these two machines. Technical characteristics of the equipment used are presented in table 3.

**Table 3: Technical characteristics of barley milling machines**

| Milling machines | Criterion | Min | Max | Average |
|---|---|---|---|---|
| Roller mills (Rm) | *Specific length (m/100kg/24h)* | 7.29 | 20.00 | 14.25 |
| | *Number of passages* | 4 | 8 | 6 |
| Stone mills (Sm) | *Specific diameter (m/100kg/24h)* | 4.00 | 15.00 | 9.22 |
| | *Number of passages* | 2 | 5 | 3 |
| Stone mills & Roller mills | Capacity (T/24h) | 20 | 30 | 25 |
| | *Diameter* (Sm) + *Length* (Rm) *(m)* | 1.6 + 2.0 | 2.4 + 1.6 | 1.6 + 2.0 |
| | *Number of passages* (Sm and Rm) | 4 (2 + 2) | 5 (3 +2) | 4 (2 +2) |

The number of passages of devices with roller mills varies from 4 to 8, and accumulates a total length ranging from 2.4 to 10 m. For mills equipped with millstones, the noted average number of grindstones is 3 for an accumulation of 2.4 m of diameter. The third group of the barley mill is the one equipped with both types of machines. We found the presence of two millstones installed in the mill head. The two roller mills are installed at the tail.

The average specific length varies depending on the type of installed machines. As a matter of fact, the present work showed that the average specific length is 14.25 mm/100 kg/24h for barley mills equipped only with roller mills. It is 9.22 mm/100 kg/24h for millstones only.

For plants equipped with the two machines, the specific length average is 12 mm/100 kg/24h which 55% came from roller mills.

Sifting is used to classify barley products according to their size. The purifiers are further installed to extract semolina for package later on. The rate of the bran varies from 0.5 to 2% depending on the number and the tuning of dehulling machines. This results mainly from the crease of dehulled grain of barley.

The specific average sifting surface observed in the surveyed mills is about **0.056 m$^2$ /100 kg / 24h**. As for purifiers, the average number per unit found during our survey, was 3 doubles (2x 46/200 mm) in 2 layers each. The milling diagram (Fig. 3) barley is simple compared to that of the common wheat or the durum wheat.

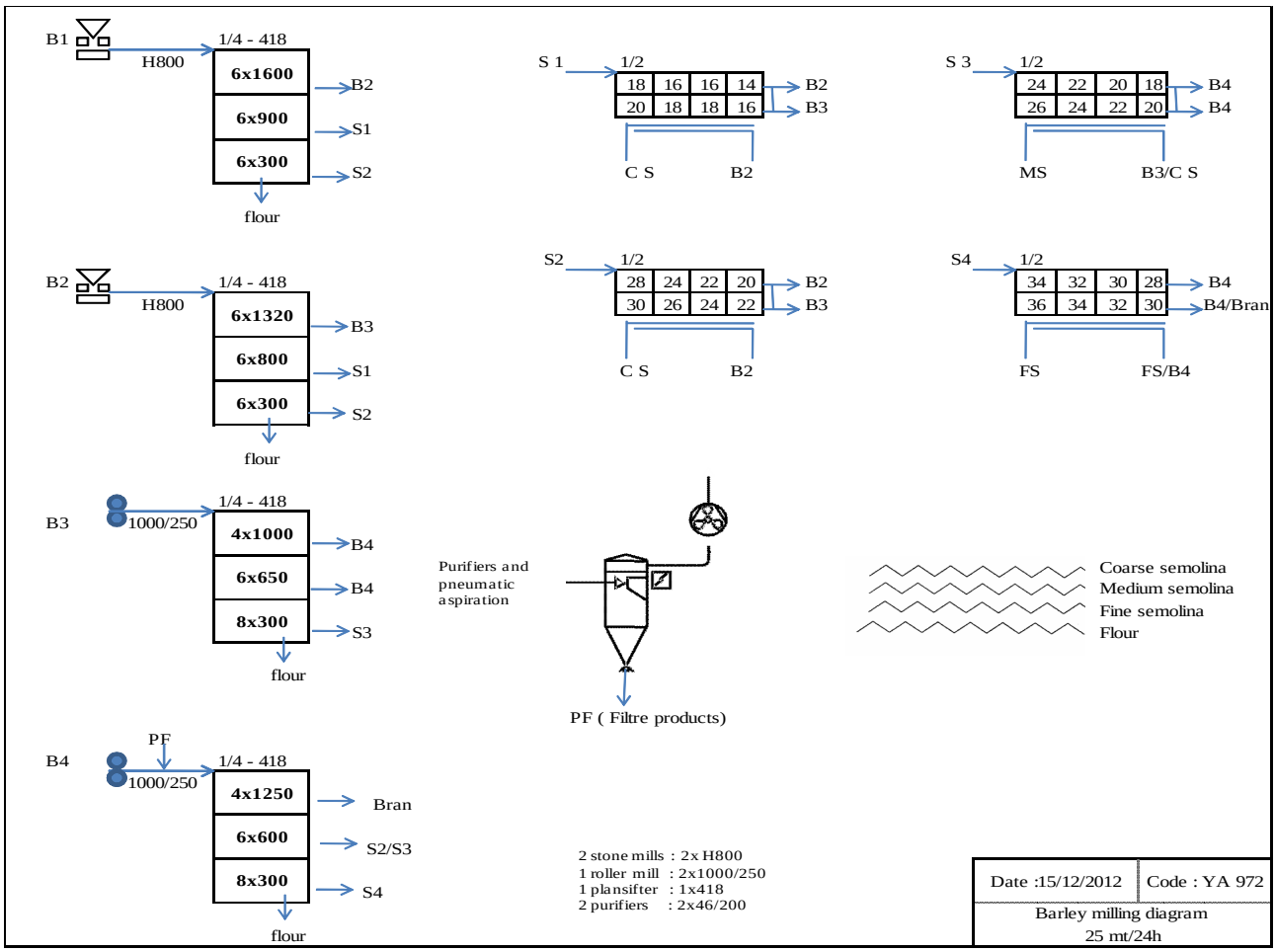


**Figure 3: Milling diagram for barley grinding**

We noticed that barley mills are characterized by their low grinding capacity and that the organization of grinding in a barley mill leans on three operations: (i) grinding or size reduction: dehulled barley grain passes between the metal rolls and / or grindstones. Products of millstones are appreciated by the consumer. This is due to the spherical shape of the obtained particles of semolina. However, semolina of this type of processing is accompanied with a high proportion of flour. Therefore, one by-product is added to the processing, (ii) sifting by the use of plansifters or rotary centrifugal sieves and (iii) purification.

For plants of gofio, barley is roasted and milled directly, without dehulling, by millstones with a diameter of one meter. The average number of millstones is three.

**3.5.8. BAGGING BARLEY PRODUCTS**

The surveyed plants are quite equipped with vents manual bagging barley products. The number of outlets varies from 2 to 4. Only two plants have carousels mouth. The barley products are packed in polypropylene bags with a variable weight 5, 10, 25 and 50 kg. The packaging paper (Kraft) used for the products of common wheat and durum wheat has not integrated yet into the activities of barley mills. As for "gofio", it is packed in bags of 900 gr.

**3.6. BARLEY PROCUREMENT ACTIVITY**

The survey showed that the barley mills stock up mainly of the market of the import. The preference of the barley of import evoked by the industrialists during our survey can be summarized as follows:

- Prickle (long extremity) of the local barley: local barley arrives at the mills with its prickle that requires a preliminary trimming. Most of the investigated barley mills do not have equipment of pre-cleaning and trimming;
- Homogeneity and cleanliness lots of local production: local barley delivered to industrial units is accompanied by a high percentage of dockage. Besides, the caliber of grains is very heterogeneous; this raises problems at the level of machines' tuning for dehulling and grinding;
- Yield of dehulling and milling: compared with barley of import, barley of local production gives low yields in dehulling and grinding because the ratio of the envelopes on the weight of the grains. The yield in the dehulling of the local barley can reach 55-60 % compared with 70-75 % for that of the import;
- Rate of integration of the local barley in the industrial grinding circuit. This rate has witnessed a strong fall. Indeed, it has passed from 53 % in 1992 to 1 % in 2012. Moreover, the average hardly exceeded 1.5% during the last decade.
- Availability of the local barley: Concerning fluctuations in the availability of barley linked to the level of the local production, the price of the local is considered by millers high raised with regard to the price of barley of import. The local barley is looked for by the breeders.

However, if it is to recommend the use of the local barley, it would be preferable to choose the varieties ***rouiza*** and ***acsad***. They better meet technological specificities of milling. They must be produced and marketed in separate circuits. They must not be mixed with other varieties.

At the national level, the annual average grinding of barley amounts to approximately 80 thousand metric ton [3]. It corresponds to a rate of use of capacity for about 25 % with regard to 50 % for the common wheat.

**3.9. OUTLOOK OF EVOLUTION OF THE BARLEY MILLLNG SECTOR**

When asked about the outlook of evolution of the barley milling sector, millers have unanimously agreed upon dropping demands on barley products. This fall is due to several factors, particularly:

- The fall in demand on the products of the barley at the level of regions traditionally known by their strong consumption. Indeed, the barley semolina which was used for the preparation of consumed soups (*dchicha or balboula*) for the breakfast was substituted by the other foodstuffs, including margarine and jam ;
- The competition of the products of common wheat, in particular the subsidized common wheat flour. In certain regions, barley semolina and flour are sold to a price more expensive than the subsidized flour and other similar flours;
- The products of the barley are generally consumed by underprivileged sectors. The persons of the middle, semi-bourgeois and bourgeois class make little appeal to the consumption of these products;
- Consumption of barley products became occasional or seasonal in certain regions. Indeed, barley products are consumed during period the winter from November till January and in the beginning of the summer (in the form of semolina with the lben, fermented milk). Other products as herbel and peeled barley are put on sale by barley mills during the month of Ramadan.

The fall in demand for barley products was at the origin of the closure of several plants or their transformation to grind other cereal, in particular the common wheat. This cereal benefits from State subsidies. However, this report is not generalized because certain plants knew an increase in their activity. They have expanded their production to get to the export market. Currently, these plants realize approximately 31 % of the national quantity grinded of barley. Besides, we noticed a certain dynamics in the installation of the production plants of Gofio in the provinces of the South of Morocco. Two new plants were installed since 2009.

## CONCLUSION

The survey led with barley plants allowed us to work out typical diagrams for cleaning, dehulling and milling. These industrial plants were able to adapt the wheat milling technology in favor of barley. Much of the equipment installed in these industrial unities comes from recycling machinery renovated mills in wheat and durum wheat.

As for the milling machines, millers attach to maintaining millstones for barley size reduction. This choice is justified by the quality of the semolina (*dchicha or balboula*) produced. Indeed, the millstones allow the obtaining semolina with spherical shape, the use of which is very appreciated by the Moroccan consumer in the form of couscous.

The industrial flour-mill is strongly competed by artisanal sector. Because of the fall in demand on barley products, the activity of certain units knew certain weakening. However, some plants were able to maintain stability in their activity thanks to actions:

- Investment in human supervision and quality control;
- Improving the quality of products and packaging;
- Opening on the export market;
- Sales contracts with manufacturing unit's couscous.

By way of conclusion, barley remains an important crop in Morocco. The renewed interest observed at the world level for the use of this cereal as functional food can stimulate the demand of the consumption. Indeed, barley grain is an excellent source of soluble and insoluble dietary fiber and other bioactive compounds such as vitamin E, B-complex vitamins, minerals and some phenolic compounds. Beta glucans (β glucans), major fiber constituent of barley, have been linked to lower plasma cholesterol, improve lipid metabolism and lower the glycemic index.

**Acknowledgements**
The authors are thankful to staffs of surveyed barley mills for their collaboration.

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